Dry film resist for fast fluidic prototyping

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DRY FILM RESIST FOR FAST FLUIDIC PROTOTYPING

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Abstract

Dry film photoresist is used for creating microfluidic structures by sandwiching the patterned resist in between of two substrates. The technique is applied for creating hybrid biochips for dielectrophoretic cell manipulation. Multiple level lithography is demonstrated and biocompatibility of the resist is proven. Due to simple fabrication procedures the resist can be processed in a low-tech environment.

Keywords: Dry film resist, microfluidics, prototyping, hybrid chips, packaging

1. Introduction

Dry film photoresists (DFR) were initially developed for fabrication of printed circuit boards. Application in MEMS technology is scarcely reported and is restricted to fabrication of electroplating moulds and masks for powderblasting of microstructures [1,2]. DFRs have several advantages over liquid resists such as good planarity of the resist, no liquid handling required, good adhesion to almost any substrate and simple fabrication process. In this paper dry film resist is demonstrated applicable for creating microfluidic structures. For this purpose Ordyl SY300 and SY550 (Elga Europe, Italy) is used, a resist that can be transferred into a rigid structure by a postbake. The resist acts as a fluidic spacer offering the possibility to integrate active elements in both bottom and top substrates. Since the simple fabrication does not necessarily require a dedicated cleanroom environment, the technique is extremely suitable for low-cost prototyping. Good compatibility with standard lithography processes and minimal number of process steps on the other hand make the technique suitable for industrial applications as well.

2. Fabrication

Photoresist (Ordyl SY300, 30 micron thickness, or SY550, 50 micron thickness) is laminated on a substrate using an office laminator (GBC 3500 pro series). Bare glass is used as a substrate, but also coated glass, silicon and a printed circuit board were tested. After removal of the first protective film, the resist is exposed for one minute with a low cost UV-lamp (TR1000, Radio Ricambi, Italy) using a photolithographic film (Tecnografika, Italy, max resolution 20 micron) as a mask. The second protective film is removed and the resist is developed and rinsed in commercially available BMR developer and rinser (Elga Europe). Increased resist thickness is realized by laminating multiple layers. A second substrate, in our case a glass lid with powderblasted holes, is bonded on top of the resist under a pressure of 650kPa and a temperature of 70°C. The temperature is ramped up in steps of 20°C per 20 min. to 150°C. A one hour postbake at 150°C transforms the resist into a rigid structure. A post-exposure bake (PEB) of 85°C for 5 min. could be inserted after exposure in order to improve the definition of the structures.

3. Results

Using the low-cost microfabrication set-up, free-standing structures of about 100µm can be achieved and channels of about 130µm for a resist thickness of 90µm (three layers of resist). A good definition of channels is more difficult than for freestanding structures due to scattering of light in the resist during UV exposure. In a cleanroom setting 20µm structures as well as 40µm channels for a resist thickness of 50µm have been achieved (details not shown).

Double bonding is easy to achieve depending on the substrate planarity, surface roughness, and PEB settings. When omitting the PEB a bonding percentage between 95 and 100% could be achieved on glass substrates (Knittel Gläser microscope slides). Inserting a PEB step puts higher constraints to the surface roughness and the planarity of the substrate. An increased resist thickness facilitates the double bonding.

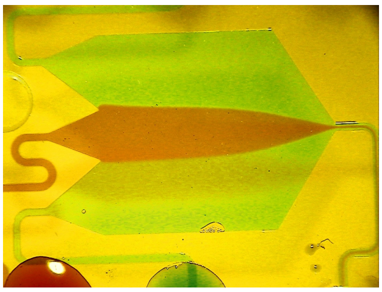

Figure 1. Three lane flow profile in a fluidic network sandwiched between a microscope glass slide and a lid with powderblasted holes.

Fluidic sealing is shown using the device in figure 1. The fluidic resist gasket is sandwiched between a microscope glass and a cover lid with powderblasted holes. Red and Blue dye are introduced in the chip and create a three lane flow-profile. The device showed neither leakages nor signs of degradation of resist or bonding quality up to a month after first usage.

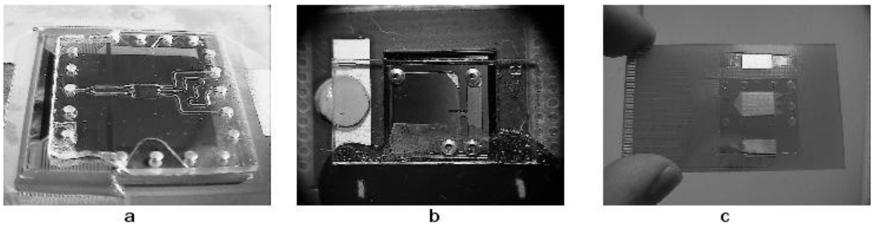

Figure 2. Series of three dielectrophoresis chips with a fluidic structure in dry film resist. All chips are closed with an ITO (Indium Tin Oxide) covered lid that is electrically connected with the bottom substrate via a conductive grease and with powderblasted holes for the fluidic interface. a) Gold and ITO patterned glass chip, wire-bonded to a PCB, b) CMOS chip, also wire bonded to a PCB, c) PCB with bare, gold plated electrodes

Figure 2 shows an ITO/gold patterned glass chip, a printed circuit board and a CMOS chip with a fluidic gasket of photoresist on top and closed by an ITO coated glass lid. The devices are meant for dielectrophoretic manipulation of biological cells and require electrodes on the bottom as well as on the top substrate for establishing the required field gradient [3,4]. The devices were successfully applied for manipulation and selective recovery of cells and beads (data not shown). Due to inexpensive and fast mask fabrication, the devices such as the ones shown can be packaged in no more than two days, including design, mask fabrication and assembly of the microfluidics.

Figure 3 shows pictures of a two level lithography process on a full silicon wafer. Since alignment of the second mask is difficult when using the low-cost UV lamp, a standard mask aligner is used (Karl Suss MA750). A PEB (85°C, 5 min) is added to improve structure definition. The same structure has been reported feasible using SU8 photoresist [5].

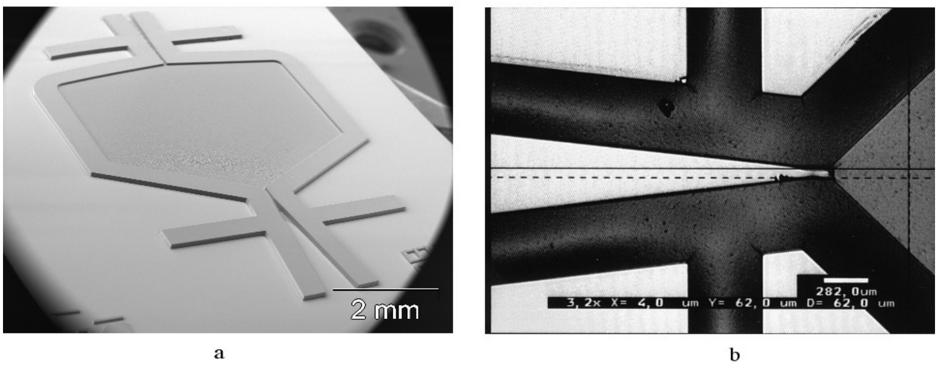

Figure 3. Two-level resist structure on a silicon substrate. a) SEM picture, b) Detail of the 50μm wide opening

Biocompatibility of the resist was proven by culturing human K562 cells for 5 days on top of a piece of processed and autoclaved resist on glass. The growth curve of the sample was compared with the growth curve of a population cultured on bare glass. The resist, both postbaked and non-postbaked, did not seem to have inhibiting effects on the cell proliferation.

4. Conclusions

A fast and inexpensive prototyping technology for microfluidic structures has been developed using dry film resist as a fluidic spacer. The resist allowed good adhesion to many substrates, simple double bonding without the use of additional adhesives and multiple lithography steps. It also has proven biocompatible. The fast and simple fabrication process makes the technique not only suitable for prototyping, but makes it interesting for industrial applications as well.

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